HYDRO STATICS

DAMS

Fluid Action on Surfaces

Dams

Dams are structures that block the flow of a river, stream, or other waterway. Some dams divert the flow of river water into a pipeline, canal, or channel.

Purpose of a Dam

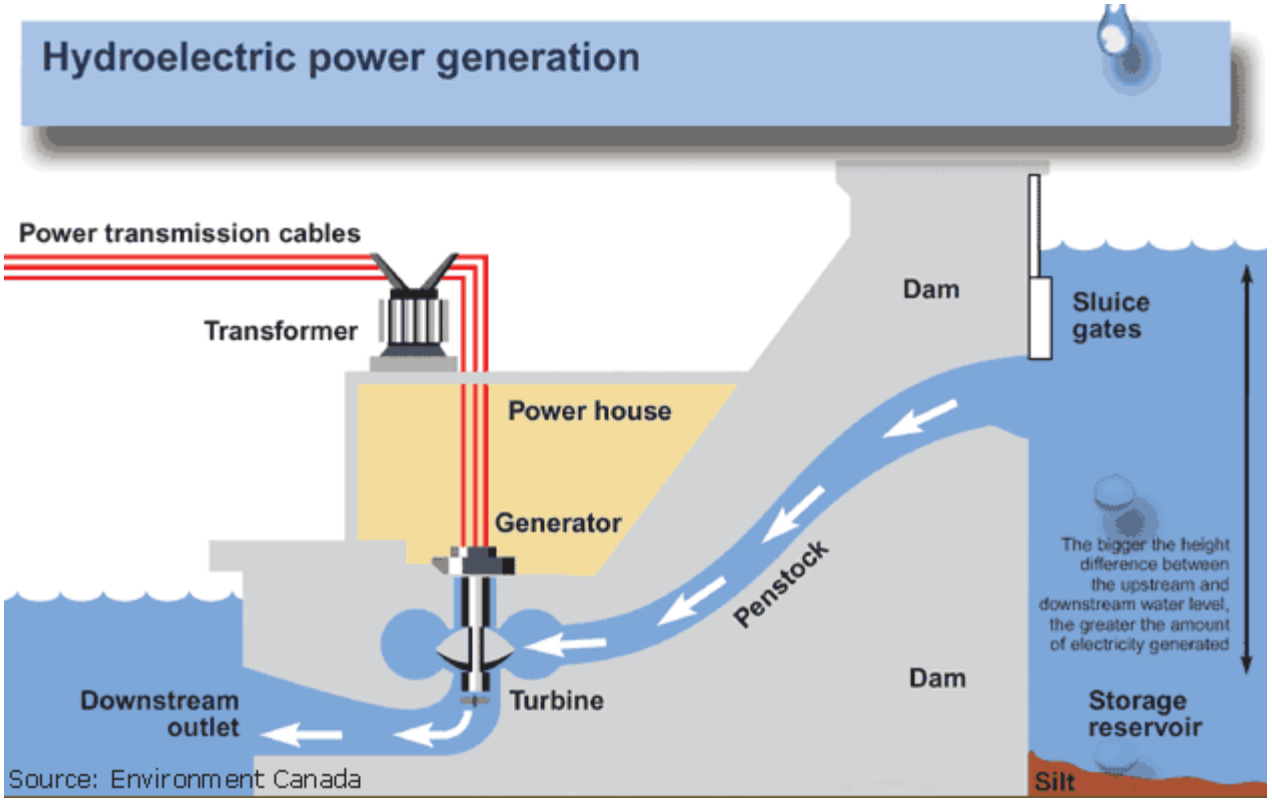
Dams are built for the following purposes:

1. Irrigation and drinking water
2. Power supply (hydroelectric)
3. Navigation
4. Flood control
5. Multi-purposes

Fluid Action on Surfaces

Dams

Section of a dam used for hydroelectric



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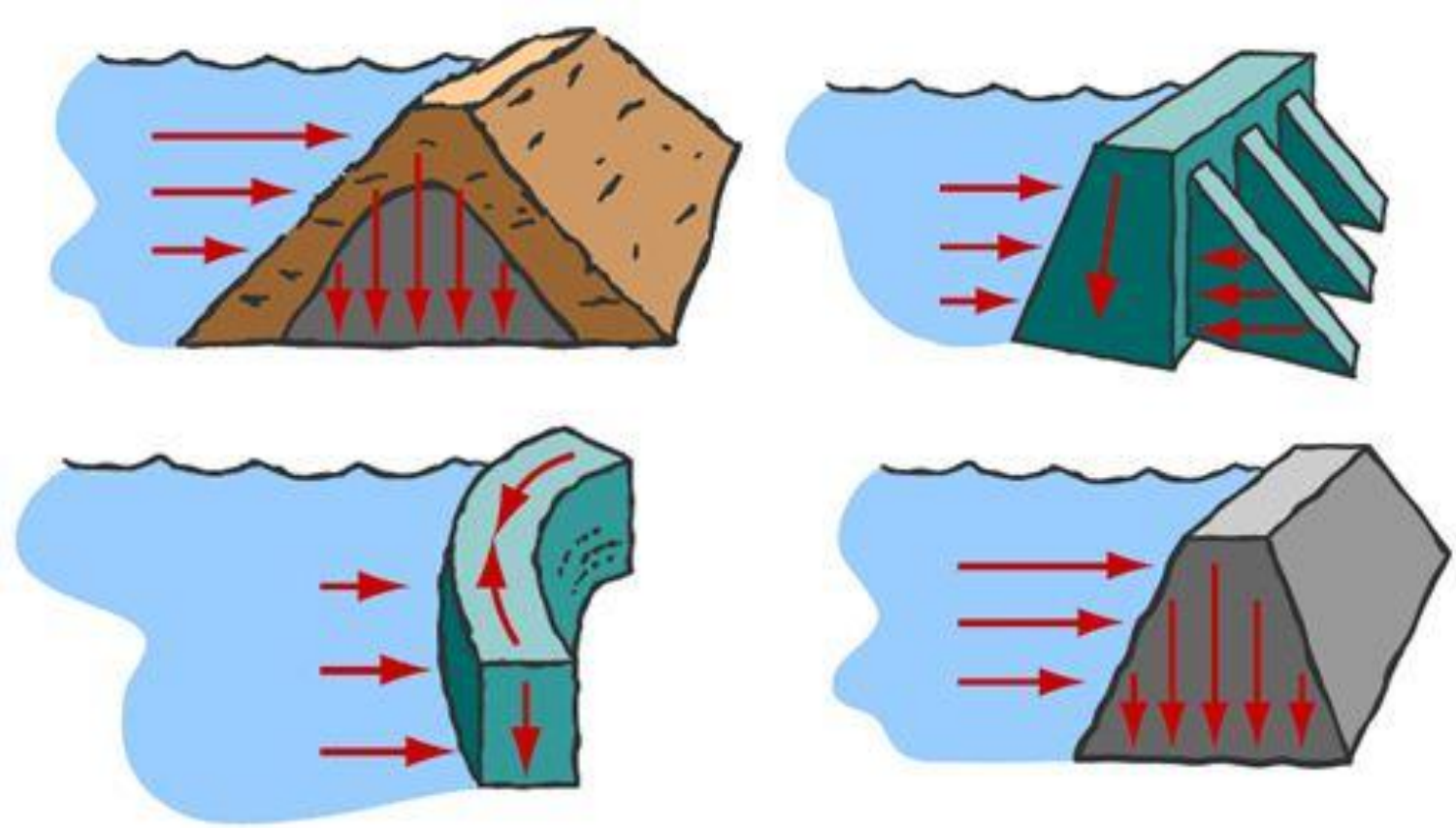
Dams

Types of Dams



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Analysis of Dams

A dam is subjected to hydrostatic forces due to water which is raised on its upstream side. These forces cause the dam to slide horizontally on its foundation and overturn it about its downstream edge or toe. These tendencies are resisted by friction on the base of the dam and gravitational forces which causes a moment opposite to the overturning moment. The dam may also be prevented from sliding by keying its base.

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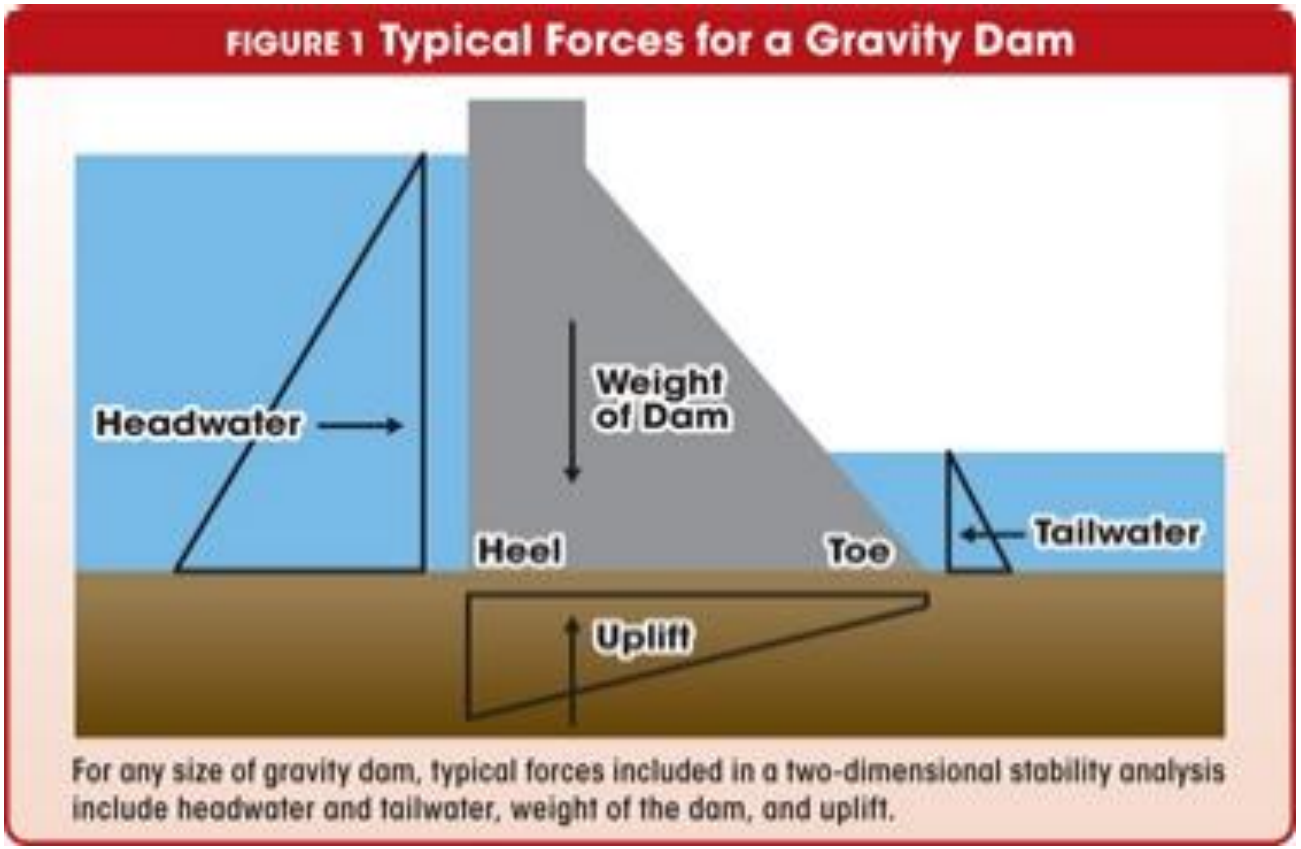
Analysis of Dams



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Analysis of Dams

1. Consider 1 unit (1 m) length of dam (perpendicular to the sketch) and identify the heel and the toe.

2. Determine all the forces acting.

   2.1 Vertical forces

   2.1.1 Weight of the dam

   2.1.2 Weight of water above the dam (if any)

   2.1.3 Weight of permanent structures on the dam

   2.1.4 Hydrostatic uplift

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Analysis of Dams

2.2 Horizontal forces

2.2.1 Total hydrostatic force acting at the vertical projection of the submerged portion of the dam

2.2.2 Other forces like wind pressure, wave action, floating bodies and earthquake load (if applicable)

3. Solve the resultant force

3.1 Vertical resultant force, R_y

$$R_y = |\Sigma F_y|$$

3.2 Horizontal resultant force, R_x

$$R_x = |\Sigma F_x|$$

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Analysis of Dams

4. Moment about the toe
   - 4.1 Overturning Moment, OM. These are the moments about the toe causing rotation towards the downstream side.
   - 4.2 Righting Moment, RM. These are the moments about the toe causing rotation towards the upstream side.

5. Location of R_y ($\bar{x}$) and e

$$\bar{x} = \frac{RM - OM}{R_y}$$

$$e = \left| \frac{B}{2} - \bar{x} \right|$$

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Analysis of Dams

6. Factor of Safety

   6.1 Against Overturning, FS_O

$$FS_O = \frac{RM}{OM} > 1.0$$

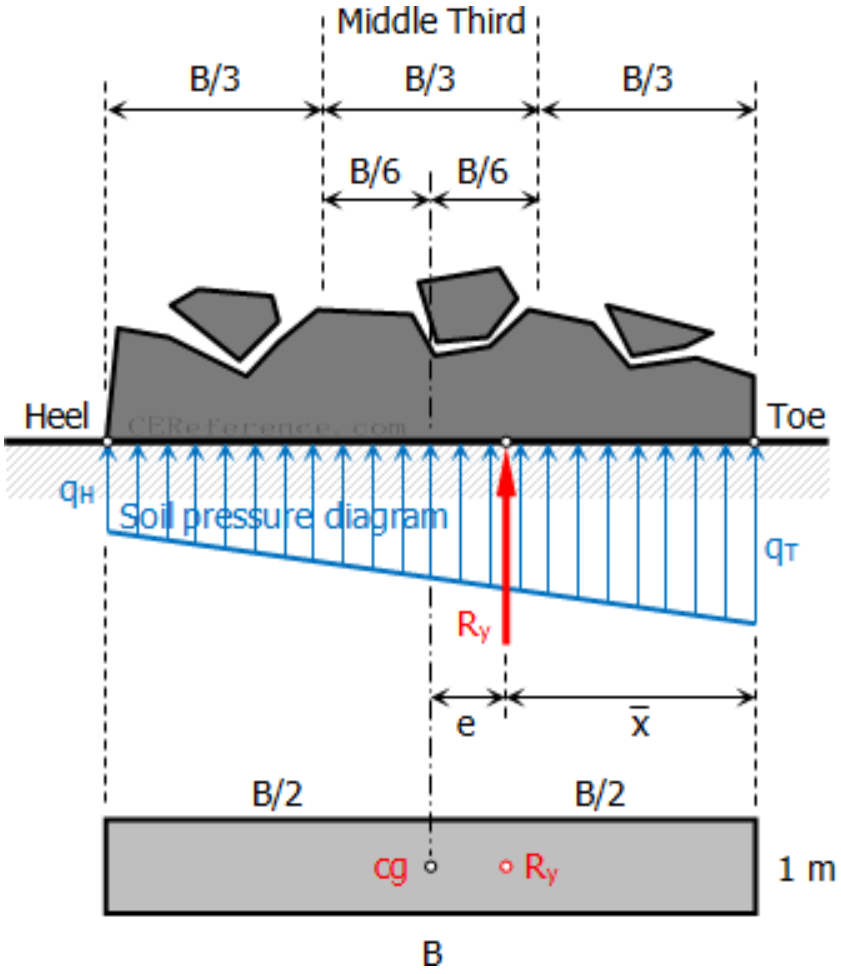
   6.2 Against Sliding, FS_S

$$FS_S = \frac{\mu R_y}{R_x} > 1.0$$

7. Foundation pressure

   7.1 If $e \leq B/6$

$$q = -\frac{R_y}{B}\left[1 \pm \frac{6e}{B}\right]$$



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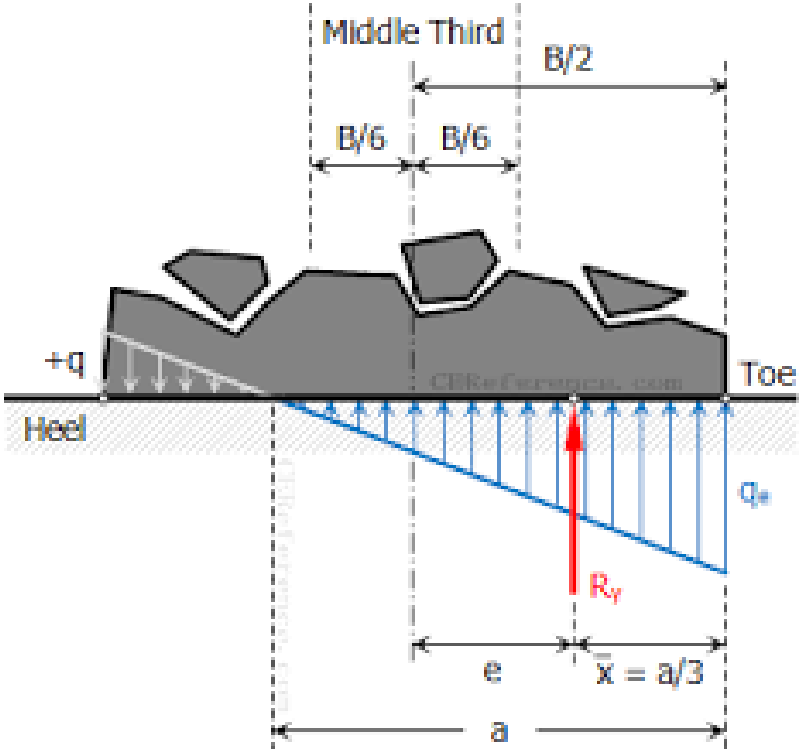
Dams

Analysis of Dams

Note: Use (+) to get the stress at point where is R_y nearest. In the diagram shown, use (+) to get q_T and (-) to get q_H . A negative stress indicates compressive stress and a positive stress indicates tensile stress.

7.2 If $e > B/6$

$$q_e = \frac{2R_y}{3\bar{x}}$$



Note:
1. The unit weight of water, γ_w, is 9.81 kN/m^3
2. The unit weight of concrete, γ_c, is usually taken as 23.5 kN/m^3
3. The μ is the coefficient of friction between the base of the dam and the foundation

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Problem Set 7

Problem 1

The section of a concrete gravity dam is shown. Unit weight of concrete is 24 kN/m^3. Hydrostatic uplift varies from 90% of the heel to 0% at the toe. Coefficient of friction between the base of the dam and the foundation is 0.80.

1.1 Calculate the factor of safety against sliding.

1.2 Calculate the factor of safety against overturning.

1.3 Calculate the distance of the R_y from the toe.

1.4 Calculate the pressure at the heel.

1.5 Calculate the pressure at the toe.

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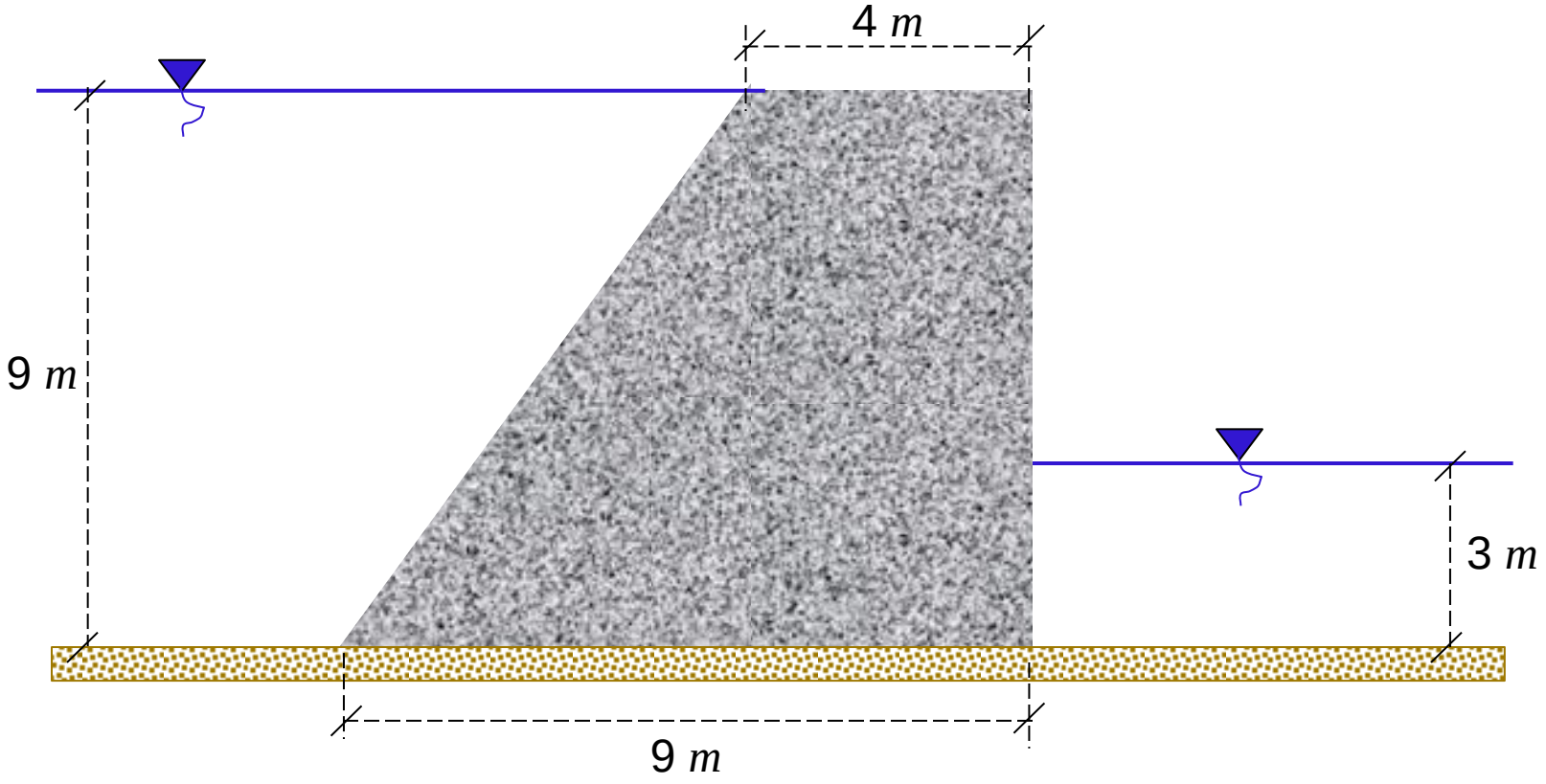
Problem Set 7

Problem 1



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Problem Set 7

Problem 2

A dam 4 m on top, 18 m at the bottom and 24 m high has water 20 m deep acting on its vertical side. Assume weight of masonry to be 2400 kg/m^3. Coefficient of friction between the base of the dam and the foundation is 0.80.

2.1 Calculate the factor of safety against overturning.

2.2 Calculate the factor of safety against sliding.

2.3 Calculate the stress at the heel.

2.4 Calculate the stress at the toe.

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Problem Set 7

Problem 3

A trapezoidal concrete dam is 20 m high. The upstream face is vertical and the water is flush with the top, which is 3 m wide. The coefficient of friction between the base of the dam and the foundation is 0.60. If it is required to have a factor of safety of 3 for overturning and knowing that specific gravity of concrete is 2.40;

3.1 Find the required width of the base.

3.2 Find the factor of safety against sliding.

3.3 Find the pressure at the heel.

3.4 Find the pressure at the toe.